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FutureHorizons
The Global Semiconductor Industry Analysts

Research Briefing: 2017/05 – An Industry Built On Sand

70th Anniversary of the Transistor Invention

The World's First Transistor (1947) & The Regency TR-1 Transistor Radio (1955)

Background

Transistors are the unsung hero of the Internet Age yet few people outside the semiconductor industry are aware they exist. The first transistor was invented at Bell Labs, New Jersey, USA on 16 December 1947 by William Shockley (seated above at Brattain's laboratory bench), John Bardeen (left) and Walter Brattain (right). This was perhaps the most important electronics event of the 20th century as it later made possible the integrated circuit (IC) and microprocessor that are the basis of modern electronics. Prior to the transistor the only alternative to its current regulation and switching functions was the vacuum tube (thermionic valve) which could only be miniaturized to a certain extent and wasted a lot of energy in the form of heat.

First shown to the world on 23 December 1947, no one really knew what to do with the invention and it was only when engineers started to appreciate that it would enable products to be built smaller, more reliably and with less power consumption that it moved from a laboratory curiosity to its first application – a hearing aid built by the US firm Sonotone in December 1952.

Partly because this was both a niche and a small market, the established electronics companies, such as RCA, Sylvania and Philco, remained slow to take the transistor bait and this reluctance opened the door for a joint collaboration between Regency, the proprietary product division of IDEA, an independent contract electronic equipment manufacturer, and Texas Instruments (TI), an up and coming transistor developer. By combining Regency's vision and radio expertise with TI's technology and strong financial backing, the world's first transistor radio, the Regency TR-1, was launched in December 1955.

Transistor Impact

Portable and pocket-sized, the Regency TR-1 was the smallest and most affordable radio that the world had ever seen and it triggered a worldwide demand for small and portable electronic products that bred the DNA for today's personal electronic devices. As Apple co-founder Steve Wozniak remarked, "Without this technology, portable media players would never have come into existence, and without that, we would not have iPhones today."

The timing was also right from a social point of view. In 1954, Bill Haley's 'Rock Around the Clock' hit the charts, along with Elvis Presley's first record, 'That's All Right Mama'. With music now in their pocket, teenagers could listen out of earshot of their disapproving parents, something the inventors had not anticipated nor were pleased about! When Regency co-founder John Pies' children became teenagers, it was common to hear "turn that music down" barked in the Pies household whilst Walter Brattain, one of the transistor co-inventors, often lamente "my only regret was that it stimulated rock and roll".

Possibly the radio's most important political and economic contribution was that it opened the floodgates of global information, decades before the information age became vogue. Its small size, battery operation and portability allowed people who had previously been denied access to outside information to have front row seats in external affairs.

From a business perspective, the Japanese company, Tokyo Tsushin Kogyo (Totsuko) quickly recognised the transistor radio's potential and entered the market in 1956 with a competitive device that quickly became the company's first big product success, leading to its eventual global consumer electronics success. Its 1957 follow-up product, under the company name now changed to Sony 'so Americans could pronounce it', was marketed as "the shirt pocket size, smallest transistorized radio in the world", with the firm's salesmen suitably equipped with oversized pocket shirts.

The importance of the TR-1 was especially clear to Thomas J. Watson, Jr., head of IBM, who used it to goad his reluctant engineers to embrace the new technology to build computers with transistors not valves. It was another event, however, that proved the tipping point for computers, namely the Soviet Union's launch of the world's first satellite (Sputnik 1) on 4 October 1957. Determined to catch up and surpass the Soviet technology, the US government turned to the semiconductor industry to build the control and guidance computers of sufficient complexity that would fit into a rocket of practical size and weight.

Industry Repercussions

The first electronic products were made from individual transistors but before long engineers learnt how to integrate several simultaneously, giving birth to the first IC in 1957. Industry development thereafter followed a predominantly evolutionary process with the number of transistors on an IC increasing exponentially each year, a process known as Moore's Law after one of the semiconductor industry's key founding fathers.

Built predominantly on silicon (sand), IC production technology successfully combined several branches of science, including physics, chemistry, mechanics, mathematics and computer sciences, to build products of ever-increasing complexity.

The TR-1 had 4 transistors; a 1971 microprocessor had 2,300; the 1978 Intel 8086 had 29,000; the 2003 Intel Pentium 4 55 million and the current Intel Skylake Xeon microprocessors 7.2 billion. The latest nVidia and AMD GPUs are over 10 billion transistors each, whilst Samsung and Micron's most advanced memory devices weigh in at a mind-boggling 40 billion.

An iPhone 8 contains around 100 billion transistors; were this made out of individual transistors it would be 60 football pitches in size and cost US$150 billion. If the same advances had been applied to, for example, the airline industry, a commercial flight between New York and London in the 1970s that cost around US$900 and took approximately seven hours would today cost less than a cent and take under a second. Not bad for an industry built on sand.

Happy 70th birthday!

Malcolm Penn

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